THE PACE OF PEDESTRIAN FLOWS IN CITIES

D. JIM WALMSLEY *is an Associate Professor in the Department of Geography and Planning at the University of New England, Australia. He is a graduate of Cambridge University and the Australian National University. His main research interests focus on the study of urban living.*

GARETH J. LEWIS *is a Senior Lecturer in the Department of Geography at the University of Leicester, England. He is a graduate of Aberystwyth and Leicester Universities. His main research interests include migration and the study of rural communities.*

ABSTRACT: The article discusses the proposition that the pace of life in big cities is faster than in other sizes of settlement, thus creating conditions conducive to the high levels of social pathology found in those cities. Observation of over 1,300 pedestrians at 10 places in Australia and England revealed that walking speed is a function of city size in that pedestrians move more quickly in big cities than in small towns. The influence of city size was, however, found to be more gradual than had been suggested in some earlier studies. In addition, the age and sex of the pedestrian, the degree of congestion in the areas under study, the time of day, and possibly even the weather had an influence on walking speed.

The observation has often been made that big cities have higher rates of social pathology than do small towns and rural areas. Two sorts of explanations are commonly offered for this phenomenon. The first dates from the turn of the century and emphasizes the way in which *societal forces* can create a situation conducive to what were previously regarded as antisocial forms of behavior. This view derived originally from writers such as Tonnies (1887) and Simmel (1969) and was closely associated with the argument that, as a result of industrialization and urbanization, the nature of society shifted from *gemeinschaft* to *gesellschaft*. In other words, the agglomeration of large

ENVIRONMENT AND BEHAVIOR, Vol. 21 No. 2, March 1989 123-150
© 1989 Sage Publications, Inc.

numbers of people from diverse social backgrounds at high densities in cities serves, it is sometimes argued, to rupture primary social contacts such as those with family members, thereby leading to a corresponding decline in social cohesiveness (Walmsley, 1988). As a result, territorially related, socially homogeneous communities based around tightly knit primary relationships (the type of social structure supposedly characteristic of *gemeinschaft* society) are replaced by a form of society where people interact in a very much more impersonal way, their relationships being compartmentalized, formal, and role directed (the stereotype of the *gesellschaft* society). According to this view, the "breakdown" of society fosters the growth of phenomena that are usually taken as indicative of social pathology (crime, vandalism, family breakdown, drug abuse, suicide, truancy) by removing constraints on antisocial behavior. The trouble with this view is, of course, that *gemeinschaft* and *gesellschaft* are really no more than caricatures (see Lewis, 1979). Additionally it is very difficult to measure societal change in such a way as to relate it directly to apparent increases in social pathology. It is not surprising, therefore, that in recent years rather more attention has focused on the second sort of explanation put forward to explain the high rate of pathology in large cities.

The second type of explanation examines how people *cope psychologically* with urban living. It first found expression in the writings of Wirth (1938). He argued that city dwellers, deprived of the sense of identity and security that comes from affiliation with a known community, become unclear about what the new social order involves. Their bewilderment can lead both to a condition known as *anomie* and to a rejection of social mores, thereby creating a basis for deviant behavior (Walmsley and Lewis, 1984). Clearly, Wirth's views are not vastly different from those of the writers who emphasized societal change as the cause of social pathology. What is of interest with Wirth's writing is, however, the fact that the focus of attention is firmly on the way in which the individual copes with change. Indeed, a central argument is that some individuals fail to cope. This view found expression in a rather more sophisticated form in Milgram's (1970) contention that many city dwellers suffer from *cognitive overload*. According to this view, the urban environment provides city dwellers with far more stimuli than they can handle. In order to cope individuals are forced to minimize essential forms of social interaction and to cut out nonessential interactions (Amato, 1981). They do this by limiting the time they allocate to certain activities (e.g., shopping becomes purely functional rather than a form of social interaction), by reducing the amount of incoming information they have to deal with (e.g., using unlisted telephone numbers), and by pursuing only superficial involvement with neighbors and other contacts. In consequence, the level of anonymity increases, particularly in big cities, and the resultant noninvolvement of individuals in the events around them creates conditions that are conducive to crime and to the legitimization of bizarre behavior and selfishness. In short, cognitive overload theory postulates that individuals have a limited amount of attention that can be allocated at any one time and that overload occurs when this capacity is exceeded. The attentional capacity of any one individual is not, however, fixed but rather can shrink when prolonged demands are made on attention or when the stress placed on the individual is intense, unpredictable, or uncontrollable (Cohen, 1978).

A number of criticisms can be made of the cognitive overload theory (Amato and McInnes, 1983). To begin with, many people enjoy highly stimulating environments and actually seek out big city life for this reason. In other words, for some people there does not seem to be any significant degree of overload. Second, understimulating environments can be just as disturbing as highly stimulating ones. Third, stimulation can make people feel good and can thereby increase affiliative behavior (e.g., eye contact) and prosocial behavior (e.g., helping with directions) (Russell and Mehrabian, 1978). In addition it may be important to distinguish physical stimulation from social stimulation. High levels of physical stimulation (noise, visual stimuli, and so on) may produce cognitive overload and a predictable withdrawal, but high levels of social stimulation may simply put people in a better mood and therefore render them more likely to be helpful to those around them (Amato, 1981).

THE PACE OF LIFE IN CITIES

The "societal change" and "psychological coping" theories have one thing in common: They both assume that the way of life that characterizes cities is both different from that in small towns and rural areas and is detrimental to human well-being. City life is commonly perceived to be more anonymous, more pressured, and more stressful. In this regard it is interesting to note that it has sometimes been claimed that the *pace of life* is quicker in cities than in small towns. Bornstein and Bornstein (1976), for example, have argued that the pace of life in cities, as measured by the speed of pedestrian flows, is a log-linear function of city size. Specifically, Bornstein and Bornstein recorded the time it took pedestrians to walk 15.24 meters (50 feet) in the downtown areas of fifteen settlements in six countries: Brno and Prague in Czechoslovakia; Corte and Bastia in France; Munich in West Germany; Psychro, Itea, Iraklion, and Athens in Greece; Safed, Dimona, Netanya, and Jerusalem in Israel; and New Haven and Brooklyn in the United States. The populations of the settlements varied from 365 (Psychro) to over 2.6 million (Brooklyn). Approximately 20 pedestrians were timed in each place (the actual numbers varying) from 10 in Psychro and Itea to 30 in Munich, Jerusalem, and Brooklyn). In all but one place pedestrians

were timed irrespective of the direction they were traveling when they covered the designated distance. The relationship found to exist between the speed of walking (S) and the population of each settlement (P), expressed in Napierian logarithms, was

$$S = 0.014 + 0.114 \log P \qquad r = +0.91$$

This is an intriguing finding, not least because of the high level of correlation. It was made all the more interesting when Bornstein (1979) studied a further six towns (Galway, Limerick, and Dublin in Eire, Inverness and Edinburgh in Scotland, and Seattle in the United States) and confirmed the earlier results, albeit with a slightly lower correlation coefficient and a slightly different regression equation:

$$S = 0.458 + P \qquad r = 0.88$$

Bornstein and Bornstein's (1976) finding is an important one. Given that walking is a standard form of human activity, any suggestion that the pace of walking is a function of city size calls for further examination. After all, the finding hints at the possibility that the pace of life in cities may ultimately approach the point of physiological breakdown given the limited motor capabilities of the human body (see Evans, 1983; Selye, 1956). In none of the settlements studied, however, was the pace of life anywhere near the levels necessary for physical dysfunction. This is possibly because the effects of physical stressors are usually mediated cognitively with a result that individuals learn to adapt to what is happening in their surroundings (Lazarus, 1966). Nevertheless, the increased speed of pedestrian flow in big cities as opposed to small towns may well be stressful to some people and this may well contribute to some individuals suffering from "overload" and manifesting their distress in one form of social pathology or another.

U.C. BERKELEY LIBRARY

Indeed, most interpretations of the relationship between walking speed and city size have assumed that people walk quickly in order to escape tension and preserve anonymity in the face of possible social interference. Smith and Knowles (1978), for example, have attributed the increased walking speed in cities to the invasion of personal space that occurs in crowded situations, although in later work they discovered that the nature of the "invader" might be critical given that artists, presumably thought to be slightly eccentric, were perceived to be less threatening than nonartists (Smith and Knowles, 1979). Similarly, it has been found that staring at pedestrians at traffic lights causes them to walk faster when given an opportunity to cross the road (Ellsworth et al., 1972).

Other researchers have interpreted increased walking speed as part of a general stress-adaptation mechanism that also includes reduced visual scanning of the environment. For instance, Korte and Grant (1980) have demonstrated that, as environmental bombardment increases, people become less aware of peripheral objects and happenings in their immediate surroundings. This suggests that, in environments containing a great many stimuli, individuals might become less aware of what is going on around them, a fact that might explain why people in noisy, crowded, urban environments are often less helpful when it comes to granting street interviews, drawing attention to dropped keys, or assisting with directions, than are people in quiet, uncrowded environments (Korte et al., 1975). Alternatively, of course, it might be that people are fully aware of what is going on but that the visual and auditory stimulation associated with big cities "energizes pedestrians" walking behavior in such a way that the resultant increased walking speed necessitates a greater attention being paid to possible obstacles in the projected path (Korte and Grant, 1980). Likewise, the apparent unhelpfulness of city dwellers in crowded environments may simply stem from the fact that, in cases where there is a large number of people perceived to be able to act, the responsibility for action is greatly diffused with a result that there is less likelihood of any one individual actually rendering assistance (Latane and Darley, 1970).

Whatever the merits of specific arguments, there exists a reasonably strong prima facie case that the pace of life, as measured by pedestrian flows, increases as a function of city size and that the higher speeds encountered in big cities impose stresses on urban dwellers. Before going one stage further and relating this to social pathology, it is as well to note some of the shortcomings of Bornstein and Bornstein's work.

To begin with, Bornstein and Bornstein were unfortunately vague about the precise placement of their observations within "downtown areas." As a consequence, the apparently greater speed in big cities might simply have resulted from the observations being made close to public transport facilities (e.g., subways, bus stops) that were absent in smaller settlements. In other words the greater speeds might have resulted from the greater need for time management (e.g., the need to rush in order to catch a particular bus) rather than from city size itself. Likewise, restricting observations to 15.24 meters left unanswered the question of whether the pace achieved over that distance could be sustained over longer distances. Intuitively it seems likely that the speed at which an individual walks will decline as the length of the journey increases.

Another weakness with Bornstein and Bornstein's methodology is that they gave no indication of the age and sex composition of their sample and yet it is widely known that both these variables have a major bearing on the speed at which people walk. Cunningham et al. (1982), for example, asked a range of men between 19 and 66 to walk "slowly," "normally," "fast," and "as fast as possible" around an indoor track in an experiment that showed that, for the over 55s, walking speed was noticeably slower than for younger groups for all four walking "styles," thereby corroborating laboratory evidence for the same phenomenon (Murray et al., 1966). Sex, too, is an important variable for two reasons: First, there is empirical evidence to show that women walk more slowly than men with a result that the proportion of women in a sample will have a big influence on the average speed of that sample (Boles and Hayward, 1978); and, second, it seems that women can cope much better than men with the high levels of crowding often found in big cities. Whereas women tend to become more cooperative and to have positive mood changes in crowded conditions, men tend to become more competitive and aggressive, a fact that perhaps explains their greater walking (i.e., escape) speed (Freedman, 1975; Amato, 1981).

Time of day is another variable not explicitly discussed by Bornstein and Bornstein but one that demands to be considered given that people have been shown to walk up to 10% more slowly at lunchtime than they do in the early morning or late afternoon (Hoel, 1968). Perhaps more important, though, is the whole question of the density and flow of pedestrians in the areas where observations are made (Kammann et al., 1979). Here, however, the evidence is somewhat equivocal. On the one hand it is possible to argue that it is difficult to walk more slowly than a crowd, and there are always strong incentives to walk more quickly, with a result that walking speed might be expected to increase as the density and volume of pedestrians increases, possibly with a concomitant decline in the standard deviation of the observed speeds (Bowerman, 1973). In contrast, Polus et al. (1983) have suggested that speed is inversely related to density. Perhaps the fact is that speed increases with density up to a critical point whereupon congestion begins to inhibit movement. Finally, the whole thrust of Bornstein and Bornstein's argument may be more apparent than real because their observations were based on extremely small sample sizes and an aggregate analysis that masked anomalies such as the fact that in Greece the people of Itea (pop. 2,500) walked more slowly than people of Psychro (pop. 365) while in Israel the people of Dimona (pop. 23,700) walked more slowly than the people of Safed (14,000). It may be, then, that the relationship between city size and walking speed is less than clear cut. Certainly figures collected by other researchers (e.g., Levine and Bartlett, 1984) have failed to match the statistical significance achieved by Bornstein and Bornstein although, overall, observations of walking speed by a wide variety of researchers do show a reasonable level of agreement (Table 1).

EXPERIMENT

In order to correct the weaknesses in Bornstein and Bornstein's methodology, and to investigate further the relationship between walking speed and city size, an experiment was conducted that compared the pace of pedestrians in Australia and England. The aim of the experiment was to see not only if walking speed varied with city size, but also whether walking speed was itself influenced by time of day, by the age and sex of the pedestrians under observation, and by weather conditions and level of pavement congestion.

In each country five settlements were studied. The towns and their 1981 populations were as follows: in Australia, Sydney (2,876,508), Newcastle (258,972), Tamworth (29,657), Armidale (18,922), and Glen Innes (6,052); in England, London (6,696,000), Leicester (282,300), Loughborough (50,919), Market Harborough (16,023), and Oakham (9,134). In each place pedestrian speeds were recorded in what was judged to be the heart of the downtown area (e.g., Oxford, Bond, and Regent Streets in London; Pitt and George Streets in Sydney). To this end a reconnaissance was made of each central business district prior to the commencement of data collection in order to select precise study areas. Delimitation of the study areas took stock of

TABLE 1
Walking Speeds in Cities (m/sec)

Place	Speed[a]	Distance	Source	Place	Speed[a]	Distance	Source
Brno	1.47	15.2m	Bornstein	Solel Beneh	1.22	2-3m	Polus et al
Prague	1.79	"	&	"	1.26	"	(1983)
Corte	1.01	"	Bornstein	Nevyim	1.21	"	"
Bastia	1.49		(1976)	"	1.23	"	"
Munich	1.71	"	"	Hechalutz	1.03	"	"
Psychro	0.84	"	"	"	1.04	"	"
Itea	0.69	"	"	Auburn	1.56/1.33[b]	9.1m	Boles (1981)
Iraklion	1.17	"	"	"	1.26/1.17[b]	"	"
Athens	1.59	"	"	"	1.80/1.68[c]	"	"
Safed	1.13	"	"	"	1.49/1.36[c]	"	"
Dimona	1.00	"	"	Harrisburg	1.33/1.20[b]	12.2m	Boles &
Netanya	1.31	"	"	"	1.31/1.13[b]	"	Hayward
Jerusalem	1.35	"	"	"	1.31/1.27[c]	"	(1978)
New Haven	1.34	"	"	New York	1.46/1.24	30.5m	Levine &
Brooklyn	1.54	"	"	Rochester	1.43/1.33	"	Bartlett
Galway	1.25	"	Bornstein	Tokyo	1.60/1.46	"	(1984)
Limerick	1.27	"	(1979)	Sendai	1.49/1.37	"	"
Dublin	1.56	"	"	Taipei	1.32/1.19	"	"
Inverness	1.43	"	"	Tainan	1.19/1.12	"	"
Edinburgh	1.51	"	"	Jakarta	1.26/1.12	"	"
Seattle	1.46	"	"	Solo	1.10/1.01	"	"
Pittsburgh	1.46	?	Hoel (1968)	Rome	1.36/1.24	"	"
Columbia	1.31/1.30	5-7m	Navin &	Florence	1.37/1.27	"	"
			Wheeler	London	1.52/1.37	"	"
			(1969)	Bristol	1.45/1.32	"	"

a. The first figure is for males, the second for females.
b. High-density conditions.
c. Low-density conditions.

what is known about pedestrian behavior as a result of the work of Ciolek (1978). Specifically, streets were selected for study so as to avoid sharp and rapid changes of either direction or elevation as well as different surfaces. Moreover, pavements were selected for study only if they were sufficiently wide to accommodate the three zones identified by Ciolek: an inner zone of 60-90 cm, largely devoid of pedestrian traffic and used mainly for stopping and window shopping; a central zone of 2-2.5m, principally used for movement; and an outer zone (the remainder of the pavement) used for such things as street furniture and bus stops. Data were collected at three time periods selected so as to avoid morning and afternoon rush hours: Period 1 0930-1030 hours, Period 2 1130-1300 hours; and Period 3 1430-1530 hours. All data collection took place in 1986 on the following weekdays: Sydney July 1-2, Newcastle July 3-4, Tamworth August 8, Armidale August 12-13, Glen Innes September 30, Leicester November 5, Loughborough November 12, Market Harborough November 19, Oakham November 26, and London December 3. Following Bornstein and Bornstein (1976), the pedestrians whose speed was recorded were those who walked alone and unencumbered, small briefcases and handbags being the only accoutrements allowed. People walking in pairs were specifically excluded because of the tendency for such groups to adapt to the pace of the slower partner and to show less agility than individuals in the face of obstacles (Boles, 1981). Also excluded were individuals obviously doing their job (e.g., postmen, couriers), those already sampled once, those known to the investigators, and people who were obviously tourists (e.g., those carrying maps or cameras) (Hill, 1984). This last category was excluded because of the possibility of bias in the sample owing to the fact that tourists were likely to be present in large numbers only in Sydney and London. Four categories of pedestrian were timed: Group 1 was males aged 20-30, Group 2 males 40-50, Group 3 females 20-30, and Group 4 females 40-50. Because pedestrians were timed surreptitiously, age was assessed visually by the investigators. The chance of error in this subjective appraisal was kept to a minimum by acting conservatively and ignoring individuals who did not clearly fall into one of the categories under study.

The speed of pedestrians was assessed by "tracking" them (see Hill, 1984). This involved selecting an individual who clearly fitted one of the categories under study and following that person along the street. Each observation began with the observer starting a stopwatch and also starting to count his own paces, having previously trained himself to walk at a standard stride length whereby one pace equaled 0.82 meters. The calibration of the stopwatch and the strides was checked each day prior to data collection. Wherever possible the observer maintained a constant distance (usually less than 10m) behind the pedestrian under study. Where the pedestrian moved so quickly that the maintenance of a constant distance would not have been possible without drawing attention to the data collection, a simple procedure was adopted: (1) the stopwatch and the stride count were started when the pedestrian and the observer were level, (2) the stopwatch was stopped when the pedestrian reached a specific point on the pavement ahead of the observer (e.g., a litter bin), and (3) the stride count was continued until the observer himself reached that specific point. Conversely, when pedestrians moved so slowly that the maintenance of a constant distance was not possible, the observer, having begun level with the pedestrian, stopped the stride count at a specific point and allowed the stopwatch to run on until the pedestrian reached that point. In other words, three things were recorded during data collection: which of the four categories of subject the pedestrian fell into; the number of paces traveled by the observer in following the pedestrian; and the time taken by the pedestrian to cover the distance in question. No trips of less than 15 paces were recorded and no trips in excess of 120 paces.

The same observer was used to pace the distances in all ten towns. The route that the observer took was reversed several times during each data collection period so as to follow pedestrians traveling in opposite directions along the same stretch of pavement. All observations were aborted if the pedestrian under study stopped, entered a shop, or otherwise stepped off the pavement. This meant that no observations were made across road intersections. No speeds were computed until data collection was completed in all ten towns. After each observation was finished the next person to be sampled was the first person to appear who clearly fitted one of the four categories under study. In short, the data collection technique had certain things in its favor: It was unobtrusive and the behavior under study was unaltered by the presence of an observer (Bechtel, 1970; Russell et al., 1976); it facilitated the timing of different lengths of journey; and it allowed speed to be assessed over natural journeys rather than over prespecified observation zones. As against this there was admittedly an element of subjectivity involved in both the sample selection (i.e., deciding whether an individual fell into one of the four categories under study) and distance measurement (i.e., the pacing technique) but this was all but eliminated by careful classification and constant calibration. The total number of observations made in each time period is shown in Table 2 together with the mean distance traveled. Most observations involved distances of 30-40m. Overall the Australian and English samples were very similar; in Australia 46% of the sample was male, in England 40%; in Australia 53% of the sample was aged 20-30, in England 56%.

At the end of each observation period a count was also made of all pedestrians passing, in either direction, along the pavement in a two-minute period. This count was made at two points characteristic of the downtown areas of Armidale, Tamworth, Market Harborough, Loughborough, and Leicester. Only one site was used in Glen Innes and Oakham on account of the smallness of their respective centers. Counts were made at three places in Sydney (a large center) and Newcastle (a very elongated center) and at 4 sites in London. From these figures values were calculated for the *pedestrian flow* (persons per meter of pavement width per minute) and *pedestrian density* (per-

U.C. BERKELEY LIBRARY

TABLE 2
The Sample

Periods:	1	2	3	Overall
Sydney: No. of observations	58	73	52	183
Mean distance walked (m)	45	49	47	–
Newcastle: No. of observations	36	53	38	127
Mean distance walked (m)	36	30	30	–
Tamworth: No. of observations	26	45	27	98
Mean distance walked (m)	37	39	35	–
Armidale: No. of observations	31	40	25	96
Mean distance walked (m)	38	42	43	–
Glen Innes: No. of observations	23	37	25	85
Mean distance walked (m)	34	42	36	–
London: No. of observations	56	97	54	207
Mean distance walked (m)	40	34	33	–
Leicester: No. of observations	52	78	53	183
Mean distance walked (m)	40	35	34	–
Loughborough: No. of observations	41	55	34	130
Mean distance walked (m)	39	35	35	–
Market Harborough: No. of observations	27	47	30	104
Mean distance walked (m)	35	37	38	–
Oakham: No. of observations	28	38	34	100
Mean distance walked (m)	36	32	32	–
TOTAL: No. of observations	378	563	372	1313

sons per square meter). Only for London were the data recorded in such a way that speed could be related to density and flow at each site; in all other cases the values for both density and flow at different sites were averaged to give an overall figure for the town in question. Note was also

taken of the maximum air temperature at the nearest weather station on the day of data collection in order to investigate the suggestion that lower temperatures lead to increased walking speeds (Hoel, 1968).

RESULTS

Once the data had been collected, one of the first questions to be asked was whether there was any relationship between the speed at which pedestrians walked and the distance over which they were timed. This is an important question because any relationship would immediately devalue Bornstein and Bornstein's (1976) results. The answer is given in Table 3, which shows the correlation between distance and speed for each time period in each settlement. Clearly correlation coefficients are very low, suggesting little relationship between the two variables. Curiously, 19 of the 30 coefficients, including the only four significant ones, show a positive relationship indicating that speed actually increased as distance increased. This flies in the face of the intuitive feeling that it is easier to sustain a high speed on a short journey than on a long one. Nevertheless, this apparently anomalous finding makes sense for a number of reasons. First, none of the speeds observed approaches the threshold at which it would be difficult to sustain motion for any period of time. Second, it may take pedestrians some time to pick up speed. This acceleration period would be masked in a long trip but may well become significant on short trips. And, third, there might have been some sorting out along the pavement such that those making long trips stayed near the outside where they could walk unimpeded whereas those on short trips walked in the more congested, and therefore slower, areas so as to be able to pop into shops.

Given the lack of any relationship between speed and distance, and thus the possibility that there may well exist a pace of pedestrian life characteristic of particular cities, it is

U.C. BERKELEY LIBRARY

TABLE 3
Correlations Between Speed and Distance Walked

		Coefficients			Coefficients
Sydney	Time 1	0.22	London	Time 1	+0.09
	Time 2	+0.05		Time 2	+0.17
	Time 3	+0.05		Time 3	+0.32*
Newcastle	Time 1	+0.34*	Leicester	Time 1	-0.01
	Time 2	+0.26		Time 2	-0.09
	Time 3	-0.06		Time 3	+0.14
Tamworth	Time 1	-0.19	Loughborough	Time 1	+0.33*
	Time 2	+0.01		Time 2	-0.01
	Time 3	.00		Time 3	+0.06
Armidale	Time 1	-0.04	Market Harborough	Time 1	-0.31
	Time 2	+0.18		Time 2	+0.13
	Time 3	+0.07		Time 3	-0.07
Glen Innes	Time 1	+0.05	Oakham	Time 1	+0.01
	Time 2	-0.07		Time 2	-0.02
	Time 3	+0.02		Time 3	+0.12

*Significant at the 95% confidence level.

TABLE 4
Walking Speeds in Australia and England (m/sec)

	1	2	3	4
Sydney: Time periods	1.57	1.53	1.62	–
1.57 (0.21)* Groups	1.63	1.61	1.55	1.48
Newcastle: Time periods	1.45	1.45	1.50	–
1.47 (0.17) Groups	1.52	1.51	1.46	1.39
Tamworth: Time periods	1.49	1.53	1.53	–
1.52 (0.16) Groups	1.56	1.56	1.52	1.46
Armidale: Time periods	1.45	1.45	1.47	–
1.46 (0.13) Groups	1.55	1.49	1.41	1.43
Glen Innes: Time periods	1.46	1.55	1.52	–
1.52 (0.12) Groups	1.58	1.51	1.50	1.48
London: Time periods	1.68	1.52	1.50	–
1.56 (0.15) Groups	1.61	1.59	1.56	1.49
Leicester: Time periods	1.62	1.59	1.65	–
1.62 (0.13) Groups	1.64	1.66	1.60	1.58
Loughborough: Time periods	1.58	1.54	1.55	–
1.56 (0.08) Groups	1.55	1.56	1.56	1.56
Market Harborough: Time periods	1.57	1.56	1.52	–
1.53 (0.09) Groups	1.58	1.56	1.54	1.53
Oakham: Time periods	1.55	1.55	1.56	–
1.45 (0.08) Groups	1.60	1.58	1.53	1.54

*The numbers under each name show the overall mean and standard deviation.

interesting to note the speeds that were actually attained. These are presented in Table 4 for both time periods and groups. The pattern is obviously a very complex one. Although the observations are very much as expected (see Table 1 for a comparison with other studies), the range is reasonably substantial. In terms of time periods, the slowest overall rate of walking was 1.45 m/sec observed in the morning and at lunchtime in both Newcastle and Armidale and the fastest rate was 1.68 m/sec in London in the morning. In terms of groups, the slowest recording was 1.39 m/sec for Group 4 in Newcastle and the fastest was 1.66 m/sec for Group 2 in Leicester. The proposition that the pace of walking is slowest at lunchtime (Hoel, 1968) seems to apply only in England. Generalizations are, in other words, difficult to make, although it does seem that women

U.C. BERKELEY LIBRARY

walk more slowly than men and older people more slowly than younger people.

The fact that pedestrians in different towns exhibit different walking speeds raises the possibility that walking speed may vary with city size, as suggested by Bornstein and Bornstein (1976). This possibility is investigated in Figure 1, which plots the log-linear regression lines between walking speed and city size. The overall figures do suggest that walking speed increases with city size, albeit very slowly and much less spectacularly than suggested by Bornstein and Bornstein. With only 5 towns used for each regression line, the overall correlation coefficients for both Australia and England proved not to be statistically significant. Nevertheless, there is some suggestion in the results that the English walk faster than Australians. The implication to be drawn from this is that cross-national comparisons, of the type attempted by Bornstein and Bornstein, may be fraught with difficulties. In terms of the time periods under investigation, the only occasion in England on which speed increased with city size was in the morning (when the correlation coefficient was significant at the 99% confidence level). At lunchtime and in the afternoon walking speed actually decreased with city size, admittedly with low levels of correlation. In Australia the picture was slightly different. At lunchtime there was again a slight decrease in speed with city size but, in this case, the afternoon figures resembled the morning at least in the slope of the regression line. This suggests that pedestrians in Australia walk more slowly in the afternoon than they do in the morning but that the overall impact of city size on walking speed is very similar to that occurring in England during the morning observation period. In terms of the groups under study, the picture in Figure 1 is interesting. Groups 1 and 2 (males) clearly walk faster than Groups 3 and 4 (females). In the case of older females in England (Group 4) there is a tendency for walking speed to decrease with city size. In Australia there is a very marginal increase in walking speed

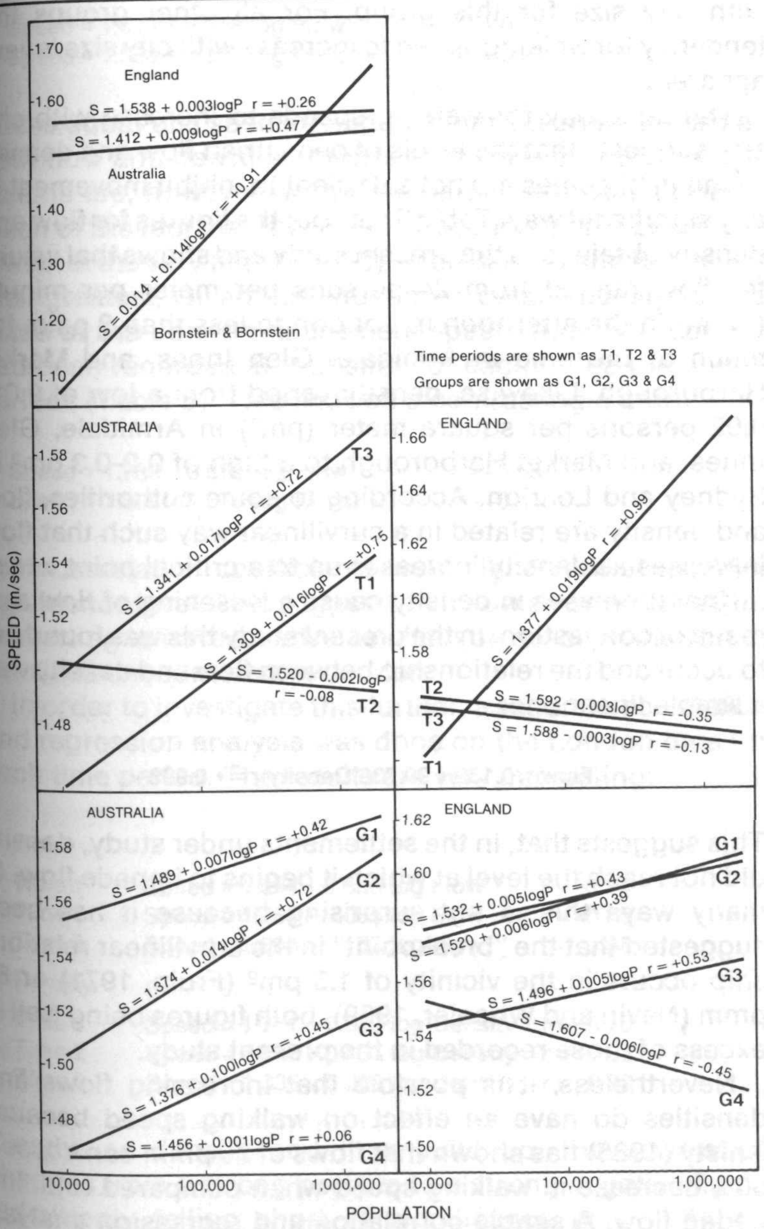

Figure 1: Speed as a Function of Population Across Countries by Groups

with city size for this group. For all other groups the tendency for walking speed to increase with city size is very apparent.

The tendency for walking speeds to increase with city size suggests that the levels of pedestrian flow and density found in big cities are not sufficient to inhibit movement in any significant way. Table 5 sets out the figures for flow and density obtained in the present study and shows that values for flow ranged from 24 persons per meter per minute (pmm) in the afternoon in London to less than 2 pmm for much of the time in Armidale, Glen Innes, and Market Harborough. Likewise, density varied from a low of 0.01-0.02 persons per square meter (pm^2) in Armidale, Glen Innes, and Market Harborough to a high of 0.2-0.3 pm^2 in Sydney and London. According to some authorities, flow and density are related in a curvilinear way such that flow increases as density increases up to a critical point where further increases in density cause a lessening of flow as a result of congestion. In the present study this was found not to occur and the relationship between flow and density was a simple linear one:

$$\text{Flow} = 0.139 + 90.736\ \text{Density} \quad r = +0.998$$

This suggests that, in the settlements under study, density did not reach the level at which it begins to impede flow. In many ways this is not surprising because it has been suggested that the "breakpoint" in the curvilinear relationship occurs in the vicinity of 1.5 pm^2 (Fruin, 1971) or 80 pmm (Navin and Wheeler, 1969), both figures being well in excess of those recorded in the present study.

Nevertheless, it is possible that increasing flows and densities do have an effect on walking speed because Khisty (1985) has shown that flows of 70 pmm can cause a 50% decrease in walking speed when compared to unimpeded flow. A simple correlation and regression analysis was used to investigate this possibility further. Working with data for all ten towns produced the following results:

$$\text{Speed} = 1.514 + 0.018 \log \text{Flow} \quad r = +0.25$$
$$\text{Speed} = 1.588 + 0.015 \log \text{Density} \quad r = +0.21$$

These equations seem to suggest that speed increases as both flow and density increase. The low correlation coefficients are, however, worrying, particularly when note is taken of the fact that the speed of pedestrians in London is lowest at the very time (Time 3) when density and flow are at their greatest. Given this situation, a detailed analysis was made of the London data where speed, flow, and density had been recorded at four sites for each of the three time periods (Table 5). This showed a contrasting picture:

$$\text{Speed} = 1.739 - 0.072 \log \text{Flow} \quad r = -0.59$$
$$\text{Speed} = 1.399 - 0.079 \log \text{Density} \quad r = -0.65$$

Both correlation coefficients were significant at the 95% confidence level. This suggests that flow and density might be starting to have an adverse effect on speed at the sort of densities encountered in London.

In order to investigate this further, a separate correlation and regression analysis was done on the London data for each time period. The results are very interesting:

Flow		
Time 1	$\text{Speed} = 1.594 + 0.039 \log \text{Flow}$	$r = +0.79$
Time 2	$\text{Speed} = 1.364 + 0.065 \log \text{Flow}$	$r = +0.65$
Time 3	$\text{Speed} = 1.804 - 0.107 \log \text{Flow}$	$r = -0.88$
Density		
Time 1	$\text{Speed} = 1.771 + 0.039 \log \text{Density}$	$r = +0.70$
Time 2	$\text{Speed} = 1.652 + 0.063 \log \text{Density}$	$r = +0.63$
Time 3	$\text{Speed} = 1.335 - 0.099 \log \text{Density}$	$r = -0.89$

Clearly, as density and flow build up, the correlation changes from a strong positive to a strong negative figure (admittedly falling short of significance at n = 4). By afternoon, when congestion was at its greatest, pedestrians moved more slowly. Of course it is not possible, from these

U.C. BERKELEY LIBRARY

TABLE 5
Pedestrian Flows and Densities

			A	B
Sydney	Time 1		7.0	.07
	Time 2		20.2	.22
	Time 3		7.9	.08
Newcastle	Time 1		2.8	.03
	Time 2		6.2	.07
	Time 3		3.3	.04
Tamworth	Time 1		6.0	.07
	Time 2		6.1	.06
	Time 3		5.4	.02
Armidale	Time 1		1.7	.02
	Time 2		2.1	.02
	Time 3		1.9	.02
Glen Innes	Time 1		0.9	.01
	Time 2		1.7	.02
	Time 3		0.9	.01
London	Time 1	Site a	6.6	.07
		Site b	13.2	.13
		Site c	5.4	.05
		Site d	2.5	.03
London	Time 2	Site a	18.3	.20
		b	19.1	.21
		c	10.7	.12
		d	9.2	.10
	Time 3	Site a	19.8	.22
		b	23.9	.27
		c	14.6	.16
		d	8.7	.09
Leicester	Time 1		7.4	.08
	Time 2		14.9	.16
	Time 3		11.1	.11
Loughborough	Time 1		5.0	.05
	Time 2		7.4	.08
	Time 3		6.3	.07
Market Harborough	Time 1		2.3	.02
	Time 2		1.9	.02
	Time 3		1.7	.02
Oakham	Time 1		4.2	.05
	Time 2		5.4	.06
	Time 3		3.1	.03

A. Represents pedestrian flow measured in people per meter per minute.
B. Represents pedestrian density measured in people per square meter.

figures, to specify the point at which impedance begins but reference back to Table 5 suggests that it might occur at flows in excess of 20 pmm and densities greater than 0.22 pm².

Another factor that may have had an influence on pedestrian behavior was the weather at the time that the observations were made. Hoel (1968) has shown that pedestrians walk faster in cold weather but this finding applies most clearly to temperatures well below those found in the present study (the Australian maxima ranged from 14° C to 21° C and the English maxima from 8° C to 12° C. Indeed at the range under study here, the difference in speed attributable to weather between Australian and English walkers, according to Hoel, should be less than 1%, far less than is necessary to explain the differences apparent in Figure 1. However a correlation between maximum temperature and walking speed for the 10 towns did produce a coefficient of -0.58. Whether this is a spurious correlation reflecting the coincidence of high temperatures in "slow" towns is unclear. It is interesting to note, however, that there was a significant correlation of +0.6 between the maximum temperature and the standard deviation for the walking speed in each town, possibly corroborating the view that, at low temperatures, a minimum speed is necessary to maintain warmth and there is therefore less scope for variation around the mean.

CONCLUSION

This article has shown that the walking speed of pedestrians in cities does increase as a function of city size. The relationship is, however, far less pronounced than was previously thought insofar as the pace of pedestrian flow in big cities is only slightly quicker than in small towns. Moreover, the actual speed at which pedestrians travel is influenced by their age and sex, by the congestion they experience, by the time of day, and possibly even by the weather. Despite this variability, some explanation is needed to account for the greater speed observed in big cities. Four reasons have been advanced by Bornstein (1979).

The first stresses *ergonomic factors*. This argument begins with the observation that walking burns up energy and goes on to postulate that differential urban-rural velocities reflect some hitherto unidentified adaptation on the part of city dwellers to the conditions under which they live. Specifically, Bornstein (1979) has claimed that walking more quickly uses more energy but also produces an increasing efficiency of positive work, *efficiency* being defined as the ratio of total mechanical work done by the muscles to net metabolic energy expenditure. This view is,

U.C. BERKELEY LIBRARY

however, very speculative. It is certainly true that muscles utilize, during shortening, some energy stored during the previous stage of stretching, but the research of physiologists seems to suggest that this leads to walking being most efficient at speeds of 1.39-1.67 m/sec, figures that are somewhat below the top speeds reportedly by Bornstein and Bornstein (Cavagna and Kaneko, 1977). Furthermore, there is laboratory evidence that minimal energy expenditure per unit of horizontal distance moved occurs at around 1.56 m/sec (Cotes and Meade, 1960). Again this is well below the speeds observed in big cities by Bornstein and Bornstein and yet remarkably similar to the overall observations made in the present study (see Figure 1). It may be then that city living merely encourages people to be as efficient as possible in their expenditure of energy.

Of course it may be that the difference between big cities and small towns has nothing to do with ergonomics but rather reflects the importance of *cognitive factors*. The best illustration of this argument is Milgram's (1970) theory of sensory overload. According to this, it is adaptive for city dwellers to withdraw cognitively from their surroundings in order to avoid overload, and cognitive withdrawal is facilitated by escape from stressful surroundings, such escape being achieved through increased walking speed. Over time, according to the argument, this adaptive mechanism evolves into a behavioral norm such that people in big cities always walk quickly in order to streamline activity.

The third possible explanation for the relationship between city size and walking speed stresses *social factors*. Although the presence of others engaged simultaneously in the same activity can impede activities such as learning, it may well be that such a presence can facilitate human performance insofar as having others around can be both motivating and arousing. Simple motor skills such as walking may be particularly sensitive to such social facilitation (Bornstein, 1979).

Finally, according to Bornstein, it may be that *economic factors* play a part in causing people in big cities to walk more quickly because, as a city grows larger, the value of its inhabitants' time increases with the city's increasing wage rate and cost of living so that economizing on time becomes more urgent and life becomes more hurried and harried (Hoch, 1976). To these four "explanations" can be added the observation that the distances that pedestrians have to walk are often greater in big cities than in small towns. Given that the length of the working/shopping day is no longer, this may mean that pedestrians in big cities find themselves in the position of having to walk quickly in order to meet geographically distant commitments within a constrained time frame. In other words, the increased pace at which pedestrians walk in big cities may be a response to time pressure rather than to city size per se. The present article did not explore this issue and it would therefore be unwise to interpret the increased walking speed observed on longer trips as a reflection of the heightened time pressure encountered in big city living, particularly as the tendency for walking speed to increase with length the trip was also apparent in the small towns under study. Nevertheless, it could be that the geographical distribution of activities, coupled with time pressure, leads to pedestrians in big cities embarking on journeys with a greater degree of purposefulness than might be the case in small towns.

It is very difficult to test these competing explanations and therefore impossible to choose among them. Further research is therefore essential if the reasons behind variations in the pace of pedestrian life are to be fully understood. In the light of the findings in this article, several lines of investigation suggest themselves. One obvious one involves the monitoring of pedestrian speed as the volume and density of pedestrian activity builds up to what might be critical levels of congestion. Likewise, it would be interesting to interview those pedestrians whose behavior is under observation in order to investigate the extent to which they feel stressed and pressured for time. In this way some insight could be gained into whether or not the proportionately greater distances that pedestrians have to cover in big cities are critical influences upon pedestrian behavior. Another possibility involves the examination of weather conditions at street level at the time of observation rather than, as in the present study, the use of maximum temperatures from nearby weather stations. It may be, for instance, that comfort levels and wind speeds have an influence on walking speed (Mumford, 1981; Sparks and Elzebda, 1983). In addition, there may of course be other variables to be taken into account that were not considered in the present study. Noise may be prominent among them. And, above all, it would be interesting to know how the pace of life varies between city centers and suburban areas irrespective of city size. The investigation of these issues, and of the pace of pedestrian flows in general, has much to offer to planners charged with the responsibility of pavement layout and pedestrianization generally. To date, the design of pedestrian areas and the placement of street furniture has paid more attention to aesthetic considerations than to behavioral considerations. Much more attention needs to be given to the study of pedestrian behavior so that environmental designers can be better informed about the consequences of both their purposive and inadvertent manipulations of pedestrian density and the pace at which pedestrians walk. Not until such further research is conducted will planners know whether they should facilitate faster pedestrian movement or seek to slow down pedestrian speed by, for instance, lowering pedestrian density.

REFERENCES

AMATO, P. R. (1981) "The impact of the built environment on prosocial and affiliative behaviour: a field study of the Townsville City Mall." Australian J. of Psychology 33: 297-303.

AMATO, P. R. and I. McINNES (1983) "Affiliative behaviour in diverse environments: a consideration of pleasantness, information rates, and the arousal-eliciting quality of settings." Basic and Applied Social Psychology 4: 109-122.

BECHTEL, R. (1970) "Human movement in architecture," pp. 642-645 in H. M. Proshansky et al. (eds.) Environmental Psychology. New York: Holt, Rinehart & Winston.

BOLES, W. (1981) "The effect of density, sex, and group size upon pedestrian walking velocity." Man-Environment Systems 11 (1-2): 37-40.

BOLES, W. E. and S. C. HAYWARD (1978) "Effects of urban noise and sidewalk density upon pedestrian cooperation and tempo." J. of Social Psychology 104: 29-35.

BORNSTEIN, M. H. (1979) "The pace of life—revisited." Int. J. of Psychology 14: 83-90.

BORNSTEIN, M. H. and H. G. BORNSTEIN (1976) "The pace of life." Nature 259: 557-559.

BOWERMAN, W. R. (1973) "Ambulatory velocity in crowded and uncrowded conditions." Perceptual and Motor Skills 36: 107-111.

CAVAGNA, G. A. and M. KANEKO (1977) "Mechanical work and efficiency in level walking and running." J. of Physiology 268: 467-481.

CIOLEK, M. T. (1978) "Spatial behaviour in pedestrian areas." Ekistics 45 (268): 120-122.

COHEN, S. (1978) "Environmental load and the allocation of attention," pp. 1-29 in A. Baum et al. (eds.) Advances in Environmental Psychology Vol. 1: The Urban Environment. Hillsdale, NJ: Lawrence Erlbaum.

COTES, J. E. and F. MEADE (1960) "The energy expenditure and mechanical energy demand in walking." Ergonomics 3: 97-119.

CUNNINGHAM, D. A., P. A. RECHNITZER, M. E. PEARCE, and A. P. DONNER (1982) "Determinants of self-selected walking pace across ages 19 to 66." J. of Gerontology 37: 560-564.

ELLSWORTH, P. C., J. M. CARLSMITH, and A. HENDERSON (1972) "The stare as a stimulus to flight in human subjects: a series of field experiments." J. of Personality and Social Psychology 21: 302-311.

EVANS, G. W. [ed.] (1983) Environmental Stress. Cambridge: Cambridge Univ. Press.

FREEDMAN, J. L. (1975) Crowding and Behavior. San Francisco: W. H. Freeman.

FRUIN, J. J. (1971) Pedestrian Planning and Design. New York: Metropolitan Association of Urban Designers and Environmental Planners.

HILL, M. R. (1984) "Stalking the urban pedestrian: a comparison of questionnaire and tracking methodologies for behavioral mapping in large-scale environments." Environment & Behavior 16: 539-550.

HOCH, I. (1976) "City size effects, trends, and policies." Science 193: 856-863.

HOEL, L. A. (1968) "Pedestrian travel rates in central business districts." Traffic Engineering 38 (4): 10-13.

KAMMANN, R., R. THOMSON, and R. IRWIN (1979) "Unhelpful behavior in the street—city size or immediate pedestrian density." Environment & Behavior 11: 245-250.

KHISTY, C. J. (1985) "Pedestrian cross flow characteristics and performance." Environment & Behavior 17: 679-695.

KORTE, C. and R. GRANT (1980) "Traffic noise, environmental awareness, and pedestrian behavior." Environment & Behavior 12: 408-420.

KORTE, C., I. YPMA, and A. TOPPEN (1975) "Helpfulness in Dutch society as a function of urbanization and environmental input level." J. of Personality and Social Psychology 32: 996-1003.

LATANE, B. and J. M. DARLEY (1970) The Unresponsive Bystander. New York: Prentice-Hall.

LAZARUS, R. (1966) Psychological Stress and the Coping Process. New York: Prentice-Hall.

LEVINE, R. V. and K. BARTLETT (1984) "Pace of life, punctuality, and coronary heart-disease in 6 countries." J. of Cross-Cultural Psychology 15: 233-255.

LEWIS, G. J. (1979) Rural Communities: A Social Geography. Newton Abbott: David & Charles.

MILGRAM, S. (1970) "The experience of living in cities." Science 167: 1461-1468.

MUMFORD, A. (1981) "Public perception of climate." Ph.D. thesis, University of Leicester.

MURRAY, M. P. et al. (1966) "Comparison of free and fast speed walking patterns of normal men." Amer. J. of Physical Medicine 45: 8-24.

NAVIN, F.P.D. and R. J. WHEELER (1969) "Pedestrian flow characteristics." Traffic Engineering 39: 30-36.

POLUS, A., J. L. SCHOFER, and A. USHPIZ (1983) "Pedestrian flow and level of service." J. of Transportation Engineering 109 (1): 46-56.

RUSSELL, J. A. and A. MEHRABIAN (1978) "Approach-avoidance and affiliation as functions of the emotion-eliciting quality of an environment." Environment & Behavior 10: 355-387.

RUSSELL, J. et al. (1976) "Informational properties of jaywalking models as determinants of imitated jaywalking: an extension to model sex, race, and number." Sociometry 39: 270-273.

SELYE, H. (1956) The Stress of Life. New York: McGraw-Hill.

SIMMEL, G. (1969) "The metropolis and mental life," in P. Sennett (ed.) Class Essays on the Culture of Cities. New York: Appleton-Century-Crofts.

SMITH, R. J. and E. S. KNOWLES (1978) "Attributional consequences of personal space invasions." Personality and Social Psychology Bull. 4: 429-433.

SMITH, R. J. and E. S. KNOWLES (1979) "Affective and cognitive mediators of reactions to spatial invasions." J. of Experimental Social Psychology 15: 437-452.

SPARKS, P. R. and J. ELZEBDA (1983) "A comparison of pedestrian comfort criteria applied to a city centre." J. of Wind Engineering and Industrial Aerodynamics 15: 123-132.

TONNIES, F. (1887) Community and Society. New York: Harper [1963 edn. trans. C. P. Loomis].

WALMSLEY, D. J. (1988) Urban Living: The Individual in the City. London: Longman.

WALMSLEY, D. J. and G. J. LEWIS (1984) Human Geography: Behavioural Approaches. London: Longman.

WIRTH, L. (1938): "Urbanism as a way of life." Amer. J. of Sociology 44: 1-24.